Report No. 212

Math

THE GRADUATE PROGRAM IN COMPUTER SCIENCE

Prepared by

Lloyd D. Fosdick, Chairman
C. W. Gear
D. Kuck
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August 25, 1966

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DEPARTMENT OF COMPUTER SCIENCE · UNIVERSITY OF ILLINOIS · URBANA, ILLINOIS

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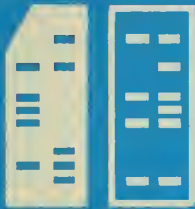
THE GRADUATE PROGRAM IN COMPUTER SCIENCE

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Department of Computer Science
University of Illinois
Urbana, Illinois

TABLE OF CONTENTS

1. INTRODUCTION

The purpose of this brochure is to help the graduate student plan an academic program in the Department of Computer Science and to describe certain matters of policy and procedure. For answers to questions not covered here the student should consult his faculty advisor.

2. ADMISSION TO GRADUATE WORK IN COMPUTER SCIENCE

An applicant will be favorably considered for admission to the Graduate College if:

(1) He is a graduate of an institution awarding a baccalaureate degree comparable to that granted by the University of Illinois;

(2) He is adequately prepared for advanced study as demonstrated by his previous program of study and his scholastic record; and

(3) He is recommended for admission by the major department or school and the Dean of the Graduate College.

In addition to satisfying these three requirements for admission to the Graduate College, he must also satisfy the prerequisites of the Department of Computer Science. These prerequisites are 20 semester hours of electrical engineering, mathematics or physics including Mathematics 294, Computer Science 201 (formerly Mathematics 295), and one of Mathematics 387, 391 or Computer Science 301 (formerly Mathematics 395) or their equivalent; because of the interdisciplinary nature of the field of computer science, the Department is willing to consider applications by students whose backgrounds do not fit into one of the above categories. Applicants should have an average of at least 4.0 (on a scale with maximum 5.0) for the last 60 hours of undergraduate work. Applicants with an average below 4.0 and above 3.75 will be considered on an individual basis.

3. FACULTY ADVISOR

A successful candidate for the graduate program in computer science will be assigned to a faculty advisor. This advisor, a member of the faculty of the Department of Computer Science, is to be consulted by the student on matters pertaining to his academic program. It is the responsibility of the student to meet with his advisor at the time of registration in order to obtain formal approval of his schedule of courses.

4. THESIS SUPERVISOR

A candidate for a graduate degree must find a supervisor for his research. This applies both to research for the M.S. thesis and for the Ph.D. thesis. In the case of the supervisor for the Ph.D. thesis, it is required that the student find this supervisor within six months after successful completion of the qualifying examination.

5. REQUIREMENTS FOR THE M.S. DEGREE IN COMPUTER SCIENCE

In order to obtain an M.S. degree in computer science, the student must satisfy the general requirements of the Graduate College. These requirements are:

(1) Eight units of satisfactory course work with at least four of them in the list "Courses for the Major." (P. 13.)

(2) Three units of these eight must be in 400-level courses.

(3) Two of these 400-level courses must be in the list "Courses for the Major." (P. 13.)

(4)   Satisfactory course work is represented by the receipt of the grade "A" or "B" in the course. The grade "C" is unsatisfactory, is regarded as a failing grade, and does not count as a unit towards a graduate degree. The student with three "C's" is disqualified as a degree candidate.

(5)   These requirements must be completed within five calendar years after first registration in the Graduate College.

(6)   The candidate must spend at least two semesters or the equivalent in residence and must earn at least half of the required units while in residence.

(7)   Residence is realized when a student lives in the community, or immediate surroundings, and devotes an appreciable portion of his time to graduate studies. A student who is regularly employed outside the Champaign-Urbana community is not considered to be in residence even though he has registered in a campus course.

In addition to satisfying these general requirements of the Graduate College, the candidate must also satisfy the following requirements of the Department: The candidate must write a thesis and is allowed one unit, CS 499 (Section A), for this project. This unit may be used as one of the eight required for the M.S. (As is implicitly indicated by the fact that just one unit of research is allowed for M.S. thesis research, this thesis is substantially simpler than a Ph.D. thesis.)

6. REQUIREMENTS FOR THE PH.D. DEGREE IN COMPUTER SCIENCE

In order to obtain a Ph.D. degree in computer science, the student must satisfy the general requirements of the Graduate College. These requirements are:

(1) Declaration of a major field of study and one approved minor, consisting of four units; or two minors, consisting of two units each, only one of which may be a division of the field of computer science.

(2) Successful completion of 16 units of graduate work, including the eight required for the M.S. degree.

(3) Eight units of thesis research.

(4) An original thesis on a topic in the field of computer science.

(5) A demonstrated ability to read two of the following languages: French, German, Russian, either by direct examination or by obtaining grades of "A" or "B" in French, German or Russian 401.

(6) The candidate must complete all requirements for this degree within seven calendar years after his first registration in the Graduate College. If the candidate has received a Master's degree elsewhere, then he must complete all requirements for the degree within five years after his first registration in the Graduate College.

(7) He must also satisfy certain residence requirements which are cited below.

In addition to these general requirements of the Graduate College the Department requires the student to pass a qualifying examination. Normally this examination will be taken after the successful completion of four units of graduate work in the field of computer science.

Students with an M.S. degree, transferring into this program, will be required to take the qualifying examination during their first year in residence. Further details on the qualifying examination are given in a paragraph below. A final departmental requirement is that at least six of the sixteen required units of course work be taken from the list of "Courses for the Major." (P. 13.)

The execution of a program of study and research towards the Ph.D. degree in computer science is marked by several stages. The first stage is completed when the candidate has received the Master's degree and has successfully passed the qualifying examination. The second stage consists of eight units of work fulfilling the major and minor course requirements, the language requirements and a preliminary examination. The preliminary examination is an oral examination designed to test the student's knowledge of his major and minor fields of study. He is not admitted to this examination until he has fulfilled the language requirements, and he has satisfactorily completed 16 units of graduate work. Finally, the third stage is devoted to research and seminars, the preparation of the thesis, and the final examination. The final examination is concerned primarily with the research accomplished by the student as described in his thesis, but may extend over the candidate's whole field of study. Two of these stages must be completed in residence and this period in residence must include two successive semesters in the second or third stage; residence is defined in the section on the M.S. degree.

7.   QUALIFYING EXAMINATION

The qualifying examination is designed to test the student's knowledge in certain important areas of computer science in order to determine whether or not he is likely to successfully complete a Ph.D. program. The examination is divided into three sections and each section into two parts.

The candidate must receive a passing grade in each section, and show high proficiency in one part of one section.

A candidate who fails the qualifying examination on his first attempt may take it one more time. He must take it at the next time it is offered.

7.1 Computer Design

1. Logical design including: realization of common computer subunits such as counters, adders and sequencers; Boolean algebra to express the behavior of switching circuits: simplification procedures; finite state machines.

2. Hardware design and devices including: realization of common computer circuits; memory mechanisms; solid state devices.

7.2 Programming and Languages

1. Programming including: encoding of information; use of hardware features; use of compiler and assembler languages; searching, sorting, and merging various data structures.

2. Languages including: processing of programs by translators, loaders, and interpreters; descriptions of formal languages and corresponding abstract machines.

7.3 Numerical Analysis

1. Computations in linear algebra including: matrix inversion; eigenvalues and eigenvectors: iterative methods.

2. Approximation including: interpolation, least squares; solution of nonlinear equations; differentiation, quadrature, and integration of ordinary differential equations.

8. BIBLIOGRAPHY FOR THE QUALIFYING EXAMINATION AREAS

The following bibliography is designed to assist students in preparing for the qualifying examination.

Computer Design

1. Bartee, T. C., I. L. Lebow and I. S. Reed, <u>Theory and Design of Digital Machines</u>, McGraw-Hill (1962).

2. Harrison, M. A. <u>Introduction to Switching and Automata Theory</u>, McGraw-Hill (1965).

3. Hohn, F. E. Applied Boolean Algebra Macmillan (1960).

4. Hurley, R. B., <u>Transistor Logic Circuits</u>, John Wiley (1958).

5. Maley, G. A., and J. Earle, <u>Logic Design of Transistor Digital Computers</u>, Prentice-Hall (1963)

6. McCluskey, E. J., <u>Introduction to the Theory of Switching Circuits</u>, McGraw-Hill (1965).

7. Miller, Raymond E., <u>Switching Theory</u>, Vols. I and II, John Wiley (1965)

8. Millman, J., and H. Taub, <u>Pulse, Digital and Switching Circuits</u>, McGraw-Hill (1965)

9. Nanavati, R. P., <u>An Introduction to Semiconductor Electronics</u>, McGraw-Hill (1963).

10. Phister, M., <u>Logical Design of Digital Computers</u>, John Wiley, (1958).

11. Poppelbaum, W. J., Lecture Notes, EE 294, (1963), EE 393, (1962-1964).

12. Ware, W. H., <u>Digital Computer Technology and Design</u>, Vols. I and II, John Wiley (1963).

Programming and Languages

1. Baumann, R., et al., <u>Introduction to ALGOL</u>, Prentice-Hall (1964)

2. Brooks, F., and K. Iverson, <u>Automatic Data Processing</u>, John Wiley (1963).

3. Chomsky, N. (Ch. 12 in Luce et al.), <u>Handbook of Mathematical Psychology</u>, Vol. II, John Wiley (1963).

4. Corbato, F., et al., <u>Advanced Computer Programming</u>, MIT Press (1963).

5. Dijkstra, E., <u>ALGOL 60 Programming</u>, Academic Press (1962).

6. Flores, I., <u>Computer Software</u> Prentice-Hall (1965)

7. Fosdick, L D., <u>7094 Programming Notes</u>, (1964).

8.   Gear, C. W., *Math 295 Classnotes*, (1960).

9.   Goodman, R., *Annual Review in Automatic Programming*, Vol. 3, Pergamon (1963).

10.   Gotlieb, C., and J. Hume, *High Speed Data Processing*, McGraw-Hill (1958)

11.   Kuck, David *Math 395 Classnotes*, (1966).

12.   Ledley, R., *Programming and Utilizing Digital Computers*, McGraw-Hill (1962).

13.   Randell, B., and L. Russell, *ALGOL 60 Implementation*, Academic Press (1964).

14.   Sherman, P., *Programming and Coding Digital Computers*, John Wiley (1963).

15.   Trakhtenbrot, B. A., *Algorithms and Automatic Computing Machines*, Heath (1963).

16.   Ware, W. H., *Digital Computer Technology and Design*, Vol. I, John Wiley (1963).

17.   Wegner, P., *Introduction to System Programming*, Academic Press (1964).

Numerical Analysis

1.   Fox, Leslie, *Numerical Methods in Linear Algebra*, Pergamon (1962).

2.   Fröberg, Carl-Erik, *Introduction to Numerican Analysis*, Addison-Wesley (1965).

3.   Hamming, R. W., *Numerical Methods for Scientists and Engineers*, McGraw-Hill (1962).

4.   Henrici, Peter, *Elements of Numerical Analysis*, John Wiley (1964).

5.   Hildebrand, F. B., *Introduction to Numerical Analysis*, McGraw-Hill (1956).

6.   Householder, A. S., *Theory of Matrices in Numerical Analysis*, Blaisdell Publishing (1964).

7.   Noble, Ben, *Numerical Methods I, II*, Interscience (1964).

8.   Ralston, Anthony, *A First Course in Numerican Analysis*, McGraw-Hill (1965).

9.   Stiefel, E. L., *An Introduction to Numerical Mathematics*, Academic Press (1963).

10.   Todd, John, (Editor), *Survey of Numerical Analysis*, McGraw-Hill (1962).

9. COURSES FOR THE MAJOR

Courses drawn from the following list may be used to satisfy the major requirement for a graduate degree in computer science.

CS 301.   Programming, Languages, and Computation. (Formerly M 395). An introduction to mathematical models of programming languages and computation on a digital computer. Phrase structure languages, particularly context free languages, and their syntactic analysis with application to translation. Abstract models of digital computers and the computations which they can perform subject to various restrictions on control, memory and time. Unsolvability results for computations and languages. 1 unit or three hours. Prerequisite: CS 101, CS 201, and senior standing or consent of instructor.

CS 306.   Machine Language and System Programming II. Principles of programming. Procedure and problem oriented languages - use and implementation. Problems in system programming for input/output channels and time sharing. 1 unit or three hours. Prerequisite: CS 201.

CS 311.   Mathematical Theory of Data Processing. (Formerly M 397) Mathematical structure and automatic processing of extensive files of data are developed employing methods from statistics, graph theory, and information theory. Topics discussed include: the selective screening and classification of data (pattern recognition, machine abstracting, optimum encoding, least square adjustment of data); and file organization and maintenance (information retrieval, indexing, scheduling). 1 unit or three hours. Prerequisite: CS 101, or consent of instructor.

CS 490.   Individual Study. May be taken more than once, subject to consent of advisor. 1/2 to 2 units.

CS 491.   Seminar in Computer Science. May be taken more than once, subject to consent of advisor. 1/2 to 2 units.

CS 497.   Topics in Computer Science. May be taken more than once, subject to consent of advisor. 1/2 to 2 units.

CS 499.   Thesis Research. There are two sections: Section A for the M.S. Thesis; Section B for the Ph.D Thesis. 0 to 4 units.

CS/EE 385.   Theory of Semiconductor Computer Devices. (Formerly EE 385).
              Crystal conduction. Large signal dc and transient behavior
              semiconductor devices. Charge storage theory, phase plane
              diagrams, tolerance optimization and noise theory. Integrated
              circuits technology: masking, oxidizing and etching. Emphasis
              on development of device-theoretical background for computer
              logic design. 3/4 unit or 1 unit or three hours. Prerequisite:
              CS/EE 294 and senior standing, or consent of instructor.

CS/EE 393.   Digital Computer Circuit Design. (Formerly EE 393.) Design of
              switching circuits and systems taking into account properties of
              currently available diodes, transistors and related circuit
              elements. Applications to slow-speed as well as high-speed
              computer circuits and data handling links. Component tolerance,
              circuit reliability and cost factors are considered. 1 unit
              or three hours. Prerequisite: CS/EE 294 or CS/M 391;
              credit or registration in EE 382 or 383, or consent of instructor.

CS/EE 394.   Logical Design of Automatic Digital Machines. (Formerly M/EE 394.)
              A course in the design of automatic digital computers. Major
              emphasis is on logical structure of components and the interrelations
              necessary for automatic operation. 1 unit or three hours.
              Prerequisite CS/EE 294, or consent of instructor

CS/EE 414.   Engineering Applications of Linear Graphs. Elementary theory
              of linear graphs, Euler graphs; incidence, cut-set and circuit
              matrices and their properties; realizability of cut-set, circuit
              and tree matrices; applications to network analysis and synthesis;
              signal flow graphs; applications to switching circuits and automata;
              communication networks. 1 unit. Prerequisite: EE 416, Math 315
              or 318.

CS/EE 456.   Coding Theory. Covers comprehensively the fundamental concepts
              and recent developments of the theory of error-correcting codes.
              Extensive discussion is given on decoding procedures and their
              implementations in computational algorithms and hardware

organizations. Also discussed are applications to computer systems such as file-addressing and matrix switches. 1 unit. Math 317 recommended but not required.

CS/EE/M 463. Information Theory. (Formerly Math 463) Mathematical models for information channels and sources; existence theorems for and construction of error-correcting codes. 1 unit. Prerequisite Mathematics 361 or Electrical Engineering 433.

CS/EE 481. Threshold Logic. Mathematical model of computer elements which work under threshold or majority principle. Mathematical theory of threshold functions. Realizability using a linear programming approach. Network syntheses of majority principle devices. 1 unit. Prerequisite: Consent of instructor.

CS/EE 482. Theory of Digital Computer Arithmetic. This course emphasizes the use of redundancy in the representation of digits in order to increase the efficiency of computer arithmetic. Topics include multiplier recoding, division with redundantly represented quotients, and structural redundancy as implied by carry-save and signed-digit techniques. 1 unit. Prerequisite: CS/EE 394.

CS/EE 485 Advanced Theory of Magnetic and Optic Computer Memory Devices. (Formerly EE 485.) Theory of ferromagnetism and superconductivity applied to memory devices. Light propagation in anistropic media: modulators and deflectors. Principles of laser operation. 1 unit. Prerequisite: CS/EE 385.

CS/M 387.   Introduction to Numerical Analysis. (Formerly M 387.) 1 unit
or three hours. Prerequisite: CS 101 and a course in differential
equations, or consent of instructor.

CS/EE/M 391.   Boolean Algebra and Switching Theory. (Formerly M/EE 391.)
Boolean algebra with applications to sets, logic, electronic
and relay combinational circuits. Karnaugh and Quine-McCluskey
minimization procedures with applications, introduction to
sequential circuits. 1/2 unit or 1 unit or three hours.
Prerequisite: Senior standing or consent of instructor.

CS/EE/M 392.   Introduction to Automata Theory. (Formerly M/EE 392.) Semigroups,
partially ordered sets, and other algebraic systems. Asynchronous
machines. Abstract synchronous machines and their properties.
Regular sets. Decomposition theory. 1/2 unit or 1 unit or three
hours. Prerequisite: CS/EE/M 391 or consent of instructor.

CS/M 457.   Advanced Numerical Analysis. (Formerly M 457.) Ordinary
differential equations: existence theory of Picard, one-step
methods, discretization error, convergence, stability, boundary
value problems; and integral equations. 1 unit. Prerequisite:
CS/M 387 or consent of instructor.

CS/M 458.   Numerical Solution of Partial Differential Equations. (Formerly
M 458.) The course deals with the numerical solution of
initial and boundary value problems for partial differential
equations. Topics include the approximation of differential
operators by difference operators, the solution of large systems
of linear equations by iterative methods, and discussion of
convergence and numerical stability. 1 unit. Prerequisite:
Math 455 or consent of instructor.

CS/M 465.   Topics in Automata Theory. (Formerly M 465.) 1 unit.
Prerequisite: CS/EE/M 392 or consent of instructor.

CS/M 487.   Theory of Approximation. (Formerly M 487) This course discusses
            general approximation theory in normed linear spaces but is
            primarily concerned with the classical cases, approximation of
            functions continuous on an interval and continuous periodic
            functions by polynomials and trigonometric polynomials.
            Existence and uniqueness theorems. Characterization of Chebyshev
            approximants. Theorems on degree of approximation. Interpolation
            with emphasis on the quality of interpolants as approximants.
            Use of approximation theory in computing. 1 unit. Prerequisites:
            M 318 , M 348 or consent of instructor.

The following additional courses may be used to satisfy the major requirements subject to the approval of the advisor.

M 412.   Recursive Function Theory. Introduction to recursive functions, study of properties of recursive and recursively enumerable sets, degrees of unsolvability, and the implications of the Church-Turing Thesis. 1 unit. Prerequisite: Math 410 or consent of instructor. (Formerly M 416.)

M 488.   Topics in Applied Mathematics. 1 unit. Prerequisite: Consent of instructor.

M 489.   Seminar in Applied Mathematics. 1 unit. Prerequisite: Consent of instructor.

EE 497.   Electrical Engineering Problems. Special electrical engineering problems. 1/2 to 2 units.

10. COURSES FOR THE MINOR

No specific requirements are made for the minor, the student is expected to consult with his advisor and select the set of courses to satisfy the requirement for the minor. Normally this choice will reflect the specialty chosen for his Ph.D. research; see the section on Research Programs.

11. RESEARCH PROGRAMS

There is opportunity for research in a wide variety of areas including:

Digital Computer Arithmetic;
Switching and Automata Theory;
Circuit Design;
Computer Organization;
Computer Applications in Physics;
Software Systems and Languages;
Numerical Analysis;
Pattern Recognition;
Information Retrieval.

Students should arrange with their advisor to work out a course of study designed to prepare them for research in one of these fields. Courses of particular importance in each of these areas are listed below.

11.1 Digital Computer Arithmetic

Students with backgrounds in Math or EE may wish to specialize in this area. The following courses should be taken by all students:

CS/EE/M 391. Boolean Algebra and Switching Theory.

CS/EE 394.   Logical Design of Automatic Digital Machines.

CS/EE 482.   Theory of Digital Computer Arithmetic.

M 317.   Introduction to Higher Algebra.

M 361, 366.   Theory of Probability.

CS/EE/M 463. Information Theory.

CS/EE 456.   Coding Theory.

Depending on the student's interests, the following courses can be added as part of the major.

CS/EE/M 392. Introduction to Automata Theory.

CS/M 465.   Topics in Automata Theory.

CS/EE 481.   Threshold Logic.

CS/EE 393.   Digital Computer Circuit Design.

CS/EE 385.   Theory of Semiconductor Computer Devices.

CS/EE 485.   Advanced Theory of Magnetic and Optic Computer Memory Devices.

CS 301.   Programming, Languages, and Computation.

CS/EE 414.   Engineering Applications of Linear Graphs.

CS/M 387.   Introduction to Numerical Analysis.

CS 311.   Mathematical Theory of Data Processing.

M 461.   Applied Stochastic Processes.

11.2 Switching and Automata Theory

Students who wish to specialize in this area must have knowledge of computer organization equivalent to CS/EE 294. The major sequence is as follows. The solid lines show the sequence by prerequisite and the broken lines a natural one although not required by prerequisite.

CS/EE/M 391

CS/EE/M 392   CS/EE 481

CS/M 465
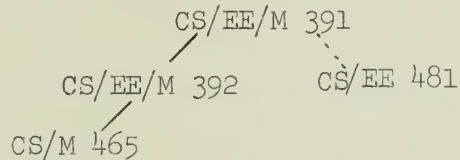
Note that this sequence does not mean that students cannot choose thesis topics in the area of CS/EE/M 391.

In addition students may take closely related courses from the following:

M 317, M 318.   Introduction to Higher Algebra.

CS/EE 394.   Logical Design of Automatic Computer Circuits.

CS/EE 482.   Theory of Digital Computer Arithmetic.

CS/EE 414.   Engineering Applications of Linear Graphs.

M 361.   Theory of Probability (or preferably a seminar of combinatorial mathematics, when it is available).

CS/EE 456.   Coding Theory.

For students who wish to specialize in logical design of computers, auditing or taking one or two of the following courses is desirable for understanding the electronics background of logical design.

EE 340, EE 341.   Electronics.

CS/EE 393.   Digital Computer Circuit Design

CS/EE 385.   Theory of Semiconductor Computer Devices.

EE 381.   Pulse Technique.

11.3 Circuit Design

The following courses comprise the recommended corpus leading to research in the physical design of computers.

CS/EE 385.	Theory of Semiconductor Computer Devices.
CS/EE/M 391.	Boolean Algebra and Switching Theory.
CS/EE/M 392.	Introduction to Automata Theory.
CS/EE 393.	Digital Computer Circuit Design.
CS/EE 485.	Advanced Theory of Magnetic and Optic Computer Memory Devices.
EE 435.	Theory of Semiconductors.
EE 472.	Quantum Electronics.
Phys. 489.	Solid State Physics I.
Phys. 490.	Solid State Physics II.
Met. 384.	Properties of Solids.

11.4   Computer Organization

Students with backgrounds in Math or EE may wish to specialize in this area. Depending on their backgrounds, interests and the particular aspects of organization that they wish to pursue, a variety of courses can be taken. The following courses are recommended for all students:

CS/EE/M 391.   Boolean Algebra and Switching Theory.

CS/EE 393.   Digital Computer Circuit Design.

CS/M 394.   Logical Design of Automatic Digital Computer Circuits.

CS 301.   Programming, Languages and Computation.

CS/EE 482.   Theory of Digital Computer Arithmetic.

CS/EE 481.   Threshold Logic.

Depending on the student's interests, the following courses can be added.

CS/EE/M 392.   Introduction to Automata Theory.

CS/M 387.   Introduction to Numerical Analysis.

CS 311   Mathematical Theory of Data Processing.

CS/M 465.   Topics in Automata Theory.

CS/EE 385.   Theory of Semiconductor Computer Devices.

EE 359.   Introduction to Noise and Information Transmission.

CS/EE 414.   Engineering Applications of Linear Graphs.

CS/EE/M 463.   Information Theory.

CS/EE 456.   Coding Theory.

11.5 Computer Applications in Physics

Students interested in this research area are advised to take
a Ph.D. in Physics. Useful courses in the computer science field are
the following:

CS/M 387.	Introduction to Numerical Analysis.
CS/M 457.	Advanced Numerical Analysis.
CS/M 458.	Numerical Solution of Partial Differential Equations.
CS/M 487.	Theory of Approximation.
CS 301.	Programming, Languages, and Computation.
CS 311.	Mathematical Theory of Data Processing.

11.6 Software Systems and Languages

This is a broad area including system programming for multi-
programmed machines, parallel multi-processors, and displays as well as
abstract questions about formal languages and translators. Depending on
his background and interest, the student will be expected to choose from
the following:

Relevant courses are:

CS 301.	Programming, Languages and Computation.
CS 311.	Mathematical Theory of Data Processing.
CS/EE/M 392.	Introduction to Automata Theory.
M 314.	Introduction to Set Theory and Mathematical Logic.
CS/EE 481.	Threshold Logic.
CS/M 465.	Topics in Automata Theory.
CS 491.	Computer Science Seminar.
	a) Pattern Recognition
	b) Topics in Formal Languages and Computation.
M 412.	Recursive Function Theory.
CS/EE 414	Engineering Applications of Linear Graphs.
CS/EE 456	Coding Theory

Additional units may be obtained from the computer science major
list as well as algebra and logic courses in mathematics.

11.7 Numerical Analysis

To successfully pursue this program, the incoming student must have previously had at least a year of calculus and a beginning course in differential equations. The major sequence of numerical analysis courses consists of:

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                           |
                           |
                     CS/Math 387
                    /             \
                   /               \
           CS/M 457                  CS/M 487
           CS/M 458
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plus seminar and special topics courses which are offered from time to time.

In addition the student should normally take or have taken the equivalent of the math sequence

Math 343.   Advanced Calculus

Math 347.   Introduction to Higher Analysis - real variables

Math 348.   Introduction to Higher Analysis - complex variables

and follow this with two or more of the sequences

(1)   Math 455 and Math 456, Mathematical Methods of Physics I and II.

(2)   Math 443 Ordinary Differential Equations and Math 444 Partial Differential Equations.

(3)   Math 440 and Math 445, Theory of Functions of a Complex Variable I and II.

(4)   Math 441 and Math 442, Real Analysis I and II.

The remaining courses can be taken in areas to fit the students special interests. Particularly recommended are the courses in programming, artificial languages, etc., such as CS 301 and suitable section of CS 497 (topics in computer science) and the sequence in logic which will be offered by the Mathematics Department.

11.8 Pattern Recognition

The most relevant courses in preparation for research in this area are:
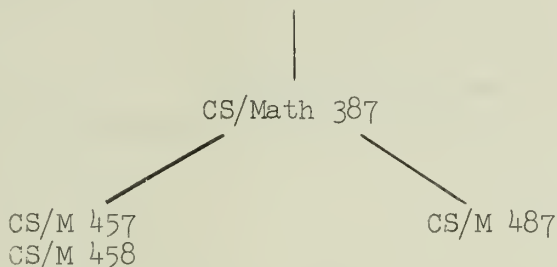
CS 301.   Programming, Languages, and Computation.

CS 311.   Mathematical Theory of Data Processing.

CS 491.   Computer Science Seminar.
              a) Pattern Recognition
              b) Topics in Formal Languages and Computation.

11.9 Information Retrieval

The principal courses preparatory to research in information retrieval are:

CS/EE/M 391.   Boolean Algebra and Switching Theory.

CS/EE/E 392.   Introduction to Automata Theory.

CS 301.   Programming, Languages, and Computation.

CS 311.   Mathematical Theory of Data Processing.

CS/M 465.   Topics in Automata Theory.

CS/EE 481.   Threshold Logic.

M 317.   Introduction to Higher Algebra.

CS/EE 414.   Engineering Applications of Linear Graphs.

M 361.   Theory of Probability.

CS/EE/M 463.   Information Theory.

CS/EE 456.   Coding Theory.

12.   RESEARCH PROGRAMS FOR STUDENTS PURSUING GRADUATE DEGREES IN OTHER DEPARTMENTS

The special facilities of the Department of Computer Science often lead students pursuing graduate degrees in electrical engineering, mathematics, or physics to focus their research activities in the Department of Computer Science. Faculty members of each of these departments are also members of the Department of Computer Science and regularly direct thesis research of such students. Any student from another department wishing to carry out his thesis research in the Department of Computer Science should consult one of these members.

The following faculty members of the Department of Computer Science are also members of the faculty of the Department of Electrical Engineering:

Professors S. Muroga, T. A. Murrell, W. J. Poppelbaum, S. R. Ray and J. E. Robertson.

The following faculty members of the Department of Computer Science are also members of the faculty of the Department of Mathematics:

Professors C. W. Gear, D. B. Gillies, J. Nievergelt and M. Paul.

The following members of the faculty of the Department of Computer Science are also members of the Department of Physics:

Professors L. D. Fosdick, B. H. McCormick, J. R. Pasta, Head of Department, J. N. Snyder, Associate Head of Department.

13. SENIOR STAFF AND RESEARCH INTERESTS

Fosdick, L. D., Professor of Physics. Computational Physics: Studies of the application of computers to the numerical solution of problems in physics.

Friedman, H. G., Assistant Professor of Chemistry. Theoretical and practical aspects of systems programming.

Gear, C. W., Associate Professor of Applied Mathematics. Numerical analysis and software systems.

Gillies, D. B., Professor of Applied Mathematics. Numerical Analysis: Experimental and theoretical studies of numerical methods adapted to computer solution of problems in analysis.

Kato, M., Visiting Associate Professor of Computer Science. Research of computer logic design and programming as well as information retrieval and pattern manipulation.

Kuck, D., Assistant Professor of Computer Science. Mathematical linguistics and applications to compiling and multi-processing. Topics in artificial intelligence.

McCormick, B. H., Professor of Physics. Pattern recognition. Construction of a high-speed computer, ILLIAC III, for the automatic scanning and processing of visual data.

Muroga, S., Professor of Electrical Engineering. Mathematical theory of circuitry and logical circuits, particularly threshold logic.

Murrell, T. A., Associate Professor of Electrical Engineering. Design of digital circuits. Transistors. Remote console computer systems.

Nievergelt, J., Assistant Professor of Mathematics. Automata theory. Organization and efficient use of large-scale parallel computers.

Pasta, J. R., Professor of Physics. Head of Department. Applications of computers to problems in physics. Computer problems associated with data analysis in high energy physics.

Paul, M., Visiting Associate Professor of Mathematics. Research on Time-sharing, Multi-programming and Remote Console Computer Systems.

Poppelbaum, W. J., Professor of Electrical Engineering. Circuit Research
    Application of hybrid circuits and electro-optics to pattern
    processing and man-machine interactions.

Ray, S. R., Associate Professor of Electrical Engineering. Studies of
    the application of content-addressable memories to pattern
    recognition.

Robertson, J. E., Professor of Electrical Engineering. Studies of efficient
    and fast methods for carrying out arithmetic operations in a
    digital computer.

Slotnick, C. L., Professor of Computer Science. Logical organization of
    large-scale computer systems. Design of a highly parallel
    computer system, ILLIAC IV.

Snyder, J. N., Professor of Physics, Associate Head of Department
    Application of digital computers to problems in physics; computer
    problems associated with data analysis in high-energy physics.

14. THE DEPARTMENT OF COMPUTER SCIENCE LIBRARY

The Department of Computer Science library maintains an exhaustive collection of journals and books covering the area of computer science and related areas, particularly mathematics and electrical engineering, augmented by a substantial number of laboratory and university reports.

The sign-out periods of the above categories of the library material is as follows:

Books, pamphlets, reports and bound journals--one month

Reference copies of bound journals,
Reference copies of books, and   overnight
Unbound journals

The following is a list of the periodicals received by the library:

ALGOL Bulletin
American Documentation
ACM Communications
ACM Journal
Applied Optics
Auerback Standard EDP Reports
Automation Express

Bell System Technical Journal
Business Week

Calcolo
Communications on Pure and Applied Mathematics
Computer Abstracts
Computer Characteristics Quarterly
Computer Design
Computer Digest
Computer Journal
Computers and Automation
Computing
Computing Reviews
Current Papers in Physics
Cybernetics

Data Processing Magazine
Datamation
D.A.T.A. Computer Logic Circuit Characteristics Tabulation
D.A.T.A. Transistor Tabulation
D.A.T.A. Semiconductor Diode and Rectifier Tabulation
Decuscope
Digital Computer Newsletter

EDP Weekly
Electronic Design
Electronic Industries
Electronic Products
Electronic Technician
Electronics
Electronics World
Elektronische Rechenanlagen
Engineering Cybernetics
European Scientific Notes

Fortune

Harvard Business Review

IBM Journal of Research and Development
IBM Systems Journal
ICC Bulletin
IEEE Spectrum
IEEE Transactions on
  - we have a subscription to all categories (about 36)
Industrial Research
Information and Control
Information Display
Information Processing in Japan
Information Storage and Retrieval
Instruments and Control Systems
International Journal of Computer Mathematics
International Science and Technology
ISA Transactions

Journal of Chemical Physics
Journal of Data Management
Journal of Differential Equations
Journal of Mathematical Analysis and Applications
Journal of Mathematical Physics
Journal of Mathematics and Mechanics
Journal of Applied Mathematics (SIAM)
Journal of Control (SIAM)
Journal of Numerical Analysis (SIAM)
Journal of Symbolic Logic
Journal of the Franklin Institute
Journal of the Optical Society of America

Kybernetik

Laser Letter

Management Science
Mathematical Algorithms
Mathematical Reviews
Mathematics of Computation
Mechanical Translation
Mitsubishi Denki Laboratory Reports
Modern Communications

Nordisk Tidskrift for Informations-Behandling
Numerische Mathematik

Operations Research

Physical Review
Physical Review Letters
Proceedings of the IEEE
Proceedings of the International Association for Analog Computation

Radio Engineering and Electronic Physics
Review: Nippon Telegraph and Telephone Public Corporation

Science
Scientific American
Semiconductor Products
SIAM Review
Simulation
Solid State Abstracts Journal

Technical Abstract Bulletin
Technical News Bulletin
Time-Sharing System Score Card

USSR Computational Mathematics and Mathematical Physics

15. RESEARCH FACILITIES

In addition to the library already described in another section, there are a number of facilities available for research in the computer science field. A selected list of these facilities is given below:

15.1 ILLIAC II Hardware Facilities

A. ILLIAC II - large scale general purpose digital computer - designed, constructed and put into service by the Department of Computer Science.

1. Online Equipment

a) Storage

2 - core boxes - 8192 words of 52 bits/word magnetic core storage (1.8 μsec.);

2 - drum boxes - 65,536 words of 52 bits/word magnetic drum storage (7 μsec.);

2 - 1301 IBM disk file - 10,000,000 words of 52 bits/word magnetic tape storage (100 μsec.);

10 - 729 Mod. VI IBM tape drives - 25,000,000 words of 52 bits/word magnetic tape storage (100 μsec.).

b) Satellite Computers

1 - 1401 IBM computer with 1-1402, 1-1403, 1-406 and 2-729 Mod. V;

1 - PDP-7 D.E.C. computer with a 630 communications control unit;

1 - D.E.C. - 338 computer controlled display unit.

c) Miscellaneous

1 - analog - digital converter with a Scully audio tape drive;

1 - digital - analog converter with an audio tape drive;

1 - multiplexing special register with 4-103A1 Bell data phones units;

1 - paper tape input output - 8 level;

    1 - Elliott 1000 ch./sec. reader;

    1 - Teletype 110 ch./sec. punch.

d) Offline Equipment

Tab. electro mechanical;

17 - 026 card punches

 1 - 082 sorter

 1 - 557 alphabetic interpreter

 1 - 514 reproducing punch

Plotting equipment;

1 - CalComp plotter Model 564 with a 670 tape drive

Communications equipment;

8 - Teletype communication consoles.

15.2 ILLIAC II Software Facilities

A. ILLIAC II

1. FORTRAN II - compiler (compatible with 7094's here);

2. NICAP - assembler language, closely related to machine language;

3. TIPSY - an interpretive processor for a simple desk calculator type of language;

4. BOOTS - a time-share system which makes possible the use of ILLIAC II from remote consoles.

B.   PDP-7

    1. FORTRAN II - compiler;

    2. Symbolic Assembler - assembler;

    3. Symbolic Tape Editor - allows use of paper tapes as if they were cards;

    4. DDT (debugging package).

15.3 IBM 7094 System

The Department of Computer Science owns an IBM 7094 computer with two IBM 1401 computers for peripheral processing. The IBM 7094/1401 facility is used for research and class work. Approximately 500 jobs per day, with over 1000 on some days, are processed by the 7094.

The PORTHOS programming system used on this 7094 was developed by professional programmers and graduate assistants in the Department. This system was designed for a university environment, with speed of throughput, ease of use and operation, automatic accounting, and generality as primary objectives in design. The 7094 has several optional features, which are used in this system, added to the hardware. Among these features are:

1) Memory protection
2) Interval timer
3) Direct data link
4) Console interrupt
5) CRT display and 35 mm film recorder
6) 1301 disk.

PORTHOS resides on the 1301 disk and provides the programmer with memory protected utility programs for input/output on the disk, tapes, printer, and CRT. Also provided are an assembler, four compilers, various interpretive systems, and the system Monitor, Loader, and Editor programs.

The various system programs developed for or implemented into PORTHOS include:

1) SCATRE - an assembler with powerful macro facilities.

2) FASTRAN - a FORTRAN II compiler with several statements added to the language. This compiler compiles shorter programs at 10 to 20 times the speed of the IBM FORTRAN compiler, with better error checking.

3) FORTRAN IBM - a slightly altered version of the IBM FORTRAN II compiler, mostly compatible with FASTRAN.

4) ALGOL - written at Illinois in cooperation with the ALCOR group, this compiler is used at many other universities. All of ALGOL-60 except the 'own' facility is implemented.

5) MAD - a slightly altered version of the Michigan Algorithm Decoder.

6) SNOBOL - a string processing language.

7) IPL-V - a list processing language.

8) LPG1 - a linear programming code.

9) SSUPAC - a package of statistical programs written and maintained by the Statistical Services Unit on campus.

10) UIEDIT - a general tape and disk editor.

11) LOADER - incorporates use of a blodked library on disk, full core loading, multiple core load (ping-pong, chain) loading, subroutine trace facilities.

12) MONITOR - through use of a single monitor to process all jobs, system time is minimized. This monitor reads and processes all control cards.

13) LOW CORE - a package of utility programs in the protected portion of memory which provides for all input/output for compilers and users. It provides for blocked, buffered, all-binary peripheral tapes for communication to the 1401 processors.

14) An extensive library of over 200 subroutines for mathematical functions, plotting, ets.

15) HAVOC - a 1401 program which allows concurrent loading of input tapes, printing and punching output tapes, and multiple copies. Batch processing of listing and reproduction jobs is possible without changing programs.

The 7094/1401 facility is in operation twenty-four hours a day, six to seven days per week. The Department provides a consulting service to research users of both the 7094 and ILLIAC II. The Consulting Office is currently open from 8 a.m. to 10 p.m., Monday through Friday, and 9 a.m. until 1 p.m. on Saturday.

15.4 Circuit Research

The circuit Research Group of the Department of Computer Science has available a very complete line of test equipment ranging from laboratory standards for dc tests to 3,000 mc reflectance bridges. Appropriate frequency sources for sine-wave, pulse and ramp operation are available for covering the gamut of frequencies up to 1,000 mc. For observation of waveforms a great number of four channel scopes are available--many of them being equipped with memory tubes.

Special hardware is available in the area of graphical processing and includes memocorders, Ardenne tubes, scanconverters, as well as closed television systems for black and white and color. Associated workshop facilities allow the production of prototype systems using printed circuit cards with several thousand active elements.

In view of large volume testing of active elements for sybsystems a certain number of automatic testing facilities are made available, these include: go no-go testers for 8 parameters as well as testers with automatic printout of the results.

16. FINANCIAL ASSISTANCE

Financial assistance in the form of fellowships, assistantships, and tuition and fee waivers are available for students in the Graduate College. Detailed information about qualifications and application procedures is given in the brochure "Financial Aid for Graduate Students," which may be obtained by writing to the Graduate College or to the Department of Computer Science. Fellows normally carry a full program of courses-- four units or the equivalent. Assistants normally work one-half time which allows them a maximum of three units of course work per semester. Other possibilities, however, are available. A table showing the nature of the appointment possible and the maximum registration permitted for each appointment is given below.

	Maximum Registration	
Nature of Appointment	Semester	Summer Semester
Full time	1 unit	1 unit
Three-fourths time	2 units	1-1/4 units
Two-thirds time	2-1/4 units	1-1/2 units
One-half time	3 units	1-3/4 units
One-third time	3-3/4 units	2 units
One-fourth time	4 units	2 units

17. TERMS AND CONDITIONS FOR ASSISTANTSHIPS IN THE DEPARTMENT OF COMPUTER SCIENCE

17.1 Proficiency in English

An applicant for admission whose native tongue is not English must take a test in English administered by the English Language Institute (ELI) unless he has a degree from a college or university in a country where English is the native language and where English is the medium of instruction. Foreign students should note that admission is denied to applicants who fail to pass the English Language Institute (ELI) test. An appointment as an assistant is conditional upon admission to the Graduate College.

17.2 Admission to the Graduate College

The application for admission will normally be forwarded to the Graduate College at the time the applicant accepts an appointment as an assistant. If he declines the offer of an assistantship, the application for admission will not be processed unless he specifically requests us to do so.

17.3 Waiver of Tuition and Fees

Assistants with appointments from 25 to 67 per cent of full-time service are exempt from the tuition and service fees, but not from the hospital-medical-insurance fee which is $10 per semester.

17.4 Acceptance and Resignation of Appointments

In every case in which a graduate scholarship, fellowship, traineeship or graduate assistantship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept another scholarship, fellowship, traineeship, or graduate assistantship. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

17.5   Course and Work Loads of Assistants

A half-time graduate assistant in the Department of Computer Science is expected to devote twenty hours per week to the project to which he is assigned.   The usual graduate course load under these circumstances is three units, or three-fourths of the full-time student load. Although we prefer that the academic interests of an assistant are in the area of computer science, this is not a condition on the employment of an assistant in the Department of Computer Science.

17.6   Renewal of Assistantships

The Department of Computer Science is usually able to continue part-time assistantships as long as both the academic progress and performance of the work of the assistant are satisfactory.

17.7   Specific Assignments

It will not be possible to inform the successful applicant of his specific assignment until about May 1.   It is only when we know with reasonable certainty which individuals plan to come that specific assignments can be made.   The assignment procedure requires consultation with project supervisors, and occurs during the two weeks following April 15.   Although we would be delighted to know the desires of the student for his assignment and will attempt to match his desires with his assignment, there can be no guarantee in each individual case that it will be possible for us to do so.

17.8   Summer Appointments

Summer employment is dependent on the availability of funds for the project to which the assistant is assigned and is dependent on the presence in Urbana during the summer of the project supervisor.   Although in the past we have been able to satisfy the desires of most assistants for summer employment, again there can be no guarantee in each individual case until about May 1.

18.   THESIS RESEARCH OF ASSISTANTS

It is the policy of the Department of Computer Science to encourage graduate students in their thesis research for the Ph.D. by assigning them to work on their theses as assistants under the supervision of a thesis advisor. This assignment is subject to the satisfactory performance of previous assignments, is subject to the availability of funds, and is subject to the prior agreement of a faculty member to serve as the thesis advisor.

The following comments are intended as guidelines for the conduct of this policy.

(1)   The assignment will normally commence at the beginning of the semester during which the preliminary examinations taken, or at the beginning of the semester immediately following the preliminary examination, and will normally be limited to three semesters at half-time.

(2)   First priority for such assignments will be given to students who have been assistants in the Department of Computer Science for two or more years.

(3)   The thesis advisor shall be a senior staff member of the Department of Computer Science. Under exceptional circumstances, a graduate student whose thesis topic is in the area of computer science but whose advisor is not a member of the Department of Computer Science may be assigned as an assistant in accordance with this policy. Such an assignment shall be at the discretion of the Head of the Department of Computer Science upon the recommendation of a member of the senior staff of the Department.

19. PREPARATION OF THESES AND MATERIAL FOR PUBLICATION

19.1 Theses

The Department will bear all expenses connected with the preparation of the thesis of any graduate student working under the direction of a senior staff member belonging to this Department. This includes expenses incurred in typing, drafting, binding and reproducing as well as the materials therefor. The administration of the Department will make proper allocation of the incurred costs to the appropriate accounts held by the Department. It should be stressed that the important criterion is that the work be done under the direction of a member of this Department, regardless of whether, or not, the candidate holds an assistantship or fellowship in this Department.

19.2 Scheduling of Thesis Preparation

All materials and copy for the final typing, drafting, etc., of the thesis must be submitted four weeks prior to the official thesis deadline in the case of a master's thesis, or by six weeks prior to the deadline in the case of a doctoral thesis. It is further expected that the student will be available during this period for consultation, questions, and proof reading. It should be stressed that the above time limits are placed on the final typing. If one or more drafts are desired these should be arranged in sufficient time to meet the deadlines above. The student in general should work closely and through his staff advisor in making arrangements for these services.

19.3 Materials for Publication

The Department will similarly bear all expenses connected with the preparation of materials for publication in accredited journals including page charges. This expense will be borne for any member or student of this Department. The important criterion in these cases will be that the published material be attributed to the Department of Computer Science in the author's by-line.

20. STUDENT HOUSING

The following housing facilities are available for graduate students.

(1) Residence Halls for single students
($360 per year for double to $518 per year single.)

(2) Student-Staff Apartments ($60 - $120 per month.)

(3) Orchard Place Apartments ($90 - $100 per month.)

(4) Orchard Downs Apartments ($95 - $125 per month.)

(5) Private Housing. The University maintains a listing of private rooms, apartments, and houses for rent.

Details on housing facilities may be obtained from:

Housing Information Office
420 Student Services Building
610 East John Street
Champaign, Illinois   61822
Phone 333-1420

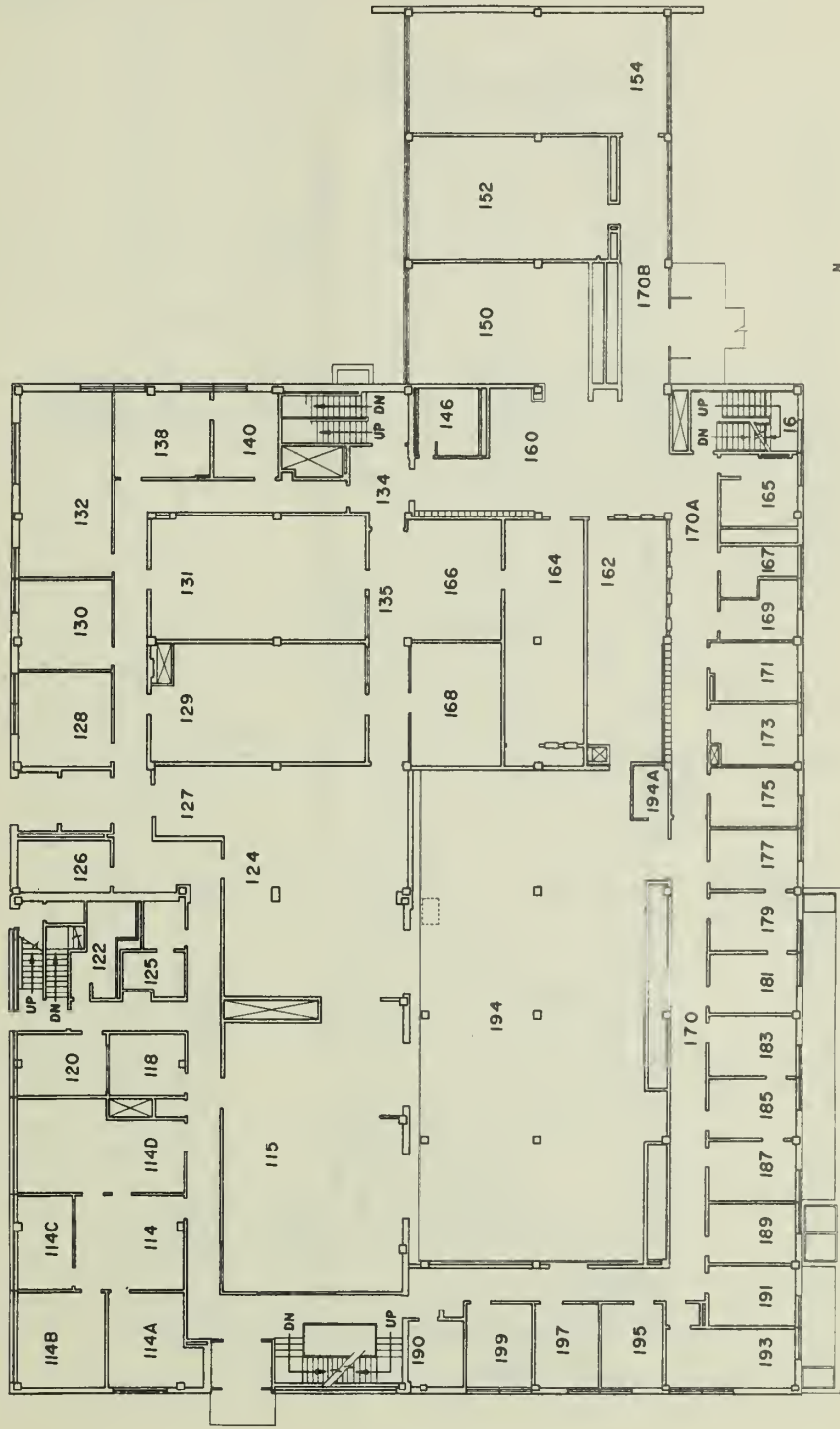A brochure "Student Housing at the University of Illinois," is helpful.

21.   MAP OF THE DEPARTMENT OF COMPUTER SCIENCE

A floor plan of the Department of Computer Science is shown on the following pages. The areas shown include office space, research laboratories, rooms for computing equipment, the library, and seminar rooms. Now shown is the basement which houses electronics shop, a metal shop, a print shop and facilities for mass production of printed circuit boards.

22.   MAP OF THE UNIVERSITY OF ILLINOIS

A map of the University of Illinois Campus, showing the location of all the buildings, with identifying numbers and the immediate surrounding area is attached.
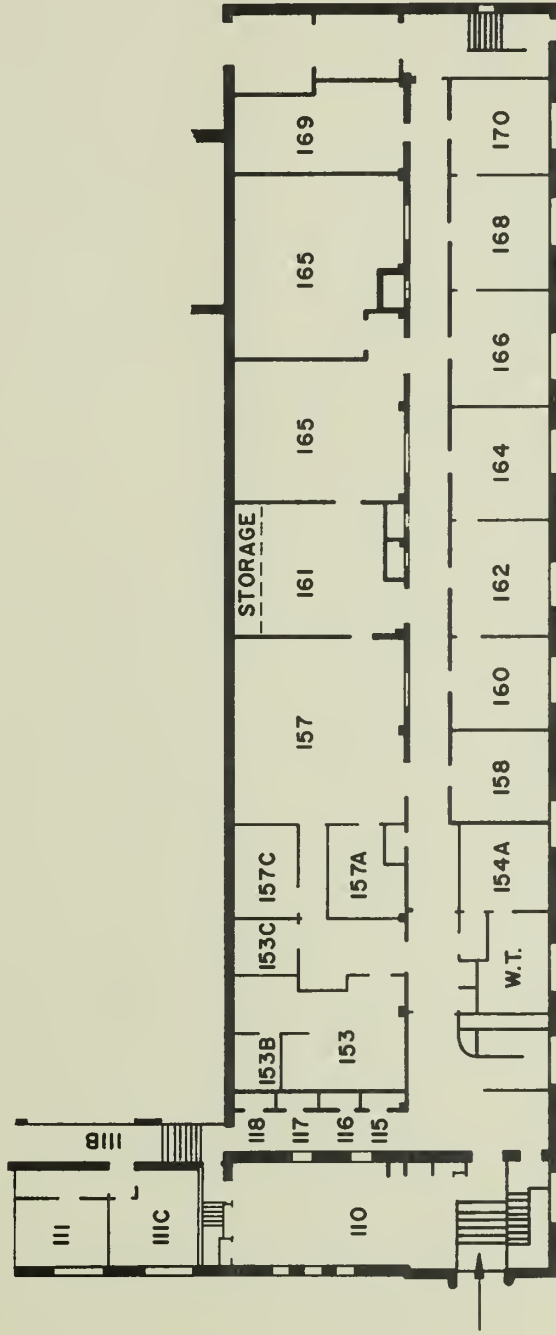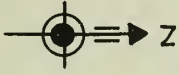
FIRST FLOOR PLAN
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DEPARTMENT OF COMPUTER SCIENCE
DIGITAL COMPUTER LABORATORY

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194 194A 170 170A 168 166 164 162 160 146 150 152 154 170B

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DEPARTMENT OF COMPUTER SCIENCE
DIGITAL COMPUTER LABORATORY

SECOND FLOOR PLAN
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ENGINEERING RESEARCH LABORATORY